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UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

Project | Date | Author

TITLE

A PROGRESS REPORT ON THE MATSUCOCCUS SITUATION ON MATURE PONDEROSA AND JEFFREY PINE IN CALIFORNIA

By
H. L. McKenzie
Berkeley, California
January 29, 1942

SUBJECT—

INDEX NO.—

U. S. GOVERNMENT PRINTING OFFICE 8—9742

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February 9, 1942

To: F. C. Craighead, In Charge, Forest Insect Investigations

From: R. C. Hall, Acting In Charge, Berkeley Laboratory

Subject: Progress Report on Matsucoccus Studies

Enclosed is a copy of "A progress report on the Matsucoccus situation on mature ponderosa and Jeffrey pine in California," and a Supplemental Memorandum on the same Progress Report, both by H. L. McKenzie.

These reports cover progress made on this problem during the 1940 and 1941 field seasons. It Represents the results of careful sampling of scale population on the twigs and branches of ponderosa pine trees in the Modoc and Lassen National Forests. The results of the 1940 study covers work from felled trees in the Modoc while the 1941 study covers work from standing trees in various stages of decadence on the Warners Bridge Climatic Plot on the Lassen Forest. The results of this study might be considered under two main headings: (1) The effect of populations of scales on the stems of twogs and branches, and (2) the effect of populations of scales in twig axils.

The Effect of Populations of Scales on Twigs

McKenzie's analysis of these data tends to show that the population of Matsucoccus on the stems of twigs and small branches of the trees examined does not appear to be associated with factors of crown decadence such as short needles, thin foliage, and retarded twig growth. He shows further that there is little association between scale population and risk; there being about as many scales per square inch on low risk trees as on those of high risk. In two trees examined the scale population was much greater on risk I trees than on those rated risk IV. Compare tree 163, risk I, and tree 211, risk IV, in table 7; and tree number 3, risk I, and tree number 8, risk IV, in table 8. A question might be raised as to why this should be. One of the possible causes for this might be that the high population of scales on the low risk trees is of recent origin, and that they have not been there sufficiently long

to have had a detrimental effect, or it may mean that these populations of scales on the stems have little effect and that it is only when they settle in the twig axils that they cause serious injury. The evidence which McKenzie submits seems to suggest the latter theory.

The Effect of Population of Scales in Twig Axils

McKenzie stresses the importance of the association of scales in the crotches with necrosis and resining and develops a very plausable picture with the data at his command. His data, although somewhat meagre, seem to well support his contention that this is the crux of the situation. However, further data are needed to substantiate this point, particularly as to cause and effect. This appears to me to be a very promising lead and one which would justify further field study.

Suggestions for Further Study

If the association of scales with necrosis and resining in axils is found, upon further study, to be consistent, it is a point which is of very practical, immediate importance in the appraisal of risk in ponderosa pine. On this basis it would appear that an additional field season should be directed to this problem. Twig axil examinations are very simple compared to stem analyses and one man should be able to make an examination of at least fifty trees in a season's work.

Further work might also be done on artificial infestation studies on a few selected twig axils in an attempt to produce necrosis and resining. At the present time the picture seems to be that scales in axils are associated with injury, but it has not been clearly demonstrated that the scales cause this injury. This phase of the work could be carried on with an expenditure of only a few man days during the coming season.

We would welcome any suggestions you might have on the future development of this problem.

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Supplemental Memorandum on the"Progress Report on the Matsucoccus Situation on Mature Ponderosa and Jeffrey Pine in California"

Since the issuance of the above mentioned progress report on Matsucoccus, additional data has been compiled further showing the effect of various degrees of twig axil resining on "current needle complement." The importance of this growth character in appraising high risk mature pines was emphasized by Mr. J. W. Bongberg. It was, therefore, deemed advisable to include needle counts made on several selected twigs from the same 4 mature ponderosa pines on the Warner's Bridge Climate Plot in Shasta County, California. Table 1 summarizes this information.

Table 1 shows that as the extent of resining in twig axils becomes greater, the current needles are fewer in number. This is in accord with the previous findings on axil injury as affecting current needle length and twig growth (see tables 3 and 4 in report).

Table 2 shows the effect of stem infestations of Matsucoccus on "current needle complement." It is questionable in this case as to whether heavy populations of scale on the stems is actually correlated with current needle reduction, because so few samples were examined.

Respectfully submitted,

H. L. McKenzie
Assistant Entomologist

Berkeley, California
February 5, 1942

Table 1. The Effect of Axil Resining on the Current Needle Complement on Twigs Cut from 4 Mature Ponderosa Pines, Shasta County, Calif.

Extent of Resining	Number Current Needles				Average Number Current Needles
	1-40	41-80	81-120	121-160	
Light	3*	8		2	64
Medium	11	2			31
Heavy	6	2			23
Total	20	12		2	

* Selected twigs examined for current number of needles.

Table 2. The Effect of Stem Infestations of Matsucoccus Scale on the Current Needle Complement on Twigs cut from 4 Mature Ponderosa Pines, Shasta County, Calif.

Average Number Scales per sq.in.	Number Current Needles				Average Number Current Needles
	1-40	41-80	81-120	121-160	
0.1-5.0	59*	24			33
5.1-10.0	59	27		3	44
10.1-15.0	5			3	19
Total	123	51		6	

* Unit samples. Each unit sample includes approximately 1.75 square inches of bark surface that was examined under the low power binocular microscope for Matsucoccus scale.

Forest Insect Laboratory
Berkeley, California
January 29, 1942

A PROGRESS REPORT ON THE MATSUCOCCUS SITUATION ON MATURE PONDEROSA AND JEFFREY PINE IN CALIFORNIA

APPROVED BY:

J. M. MILLER
Senior Entomologist, In Charge

SUBMITTED BY

H. L. MCKENZIE
Assistant Entomologist

A PROGRESS REPORT ON THE MATSUCOCCUS SITUATION ON MATURE PONDEROSA AND JEFFREY PINE IN CALIFORNIA

This report is an attempt to summarize the more pertinent information regarding the role Matsucoccus plays in the deterioration of mature ponderosa and Jeffrey pine in California forests. These forest scale investigations actually started during the fall season of 1939. Considerable time was first given to the bole-feeding margarodid, Matsucoccus californicus Morrison, the occurrence of which had been previously observed by other workers in forest entomology. The preliminary experiments on this insect showed no particular association of scale abundance on the bole of trees recently attacked by bark beetles or on trees exhibiting marked decadence. Certain trees did show such a relationship, although as a whole this correlation did not exist.

The presence of various species of Matsucoccus, the most important of which appears to be M. bisetosus Morrison on the stems and branches of mature pines, was not discovered until sometime later. This lead appeared much more significant in view of the information previously obtained on several other stem-feeding species of this group. Therefore, during the spring of 1940 several vigorous and decadent mature pines were selected and felled on the Modoc National Forest in California, and branches from various parts of the crown of these trees were cut and brought into the Berkeley Laboratory for examinations. The stems of branches from 8 of these trees were carefully analyzed for scale abundance. The results of these tests are included in this report. During the 1940 season some attention was given to the resining of twig axils, although it was not until 1941 that this phase of scale damage was actually more carefully dealt with.

In 1941, 4 mature ponderosa pines, 2 of which were vigorous and 2 decadent, on the Warner's Bridge Climate Plot, Shasta County, California, were selected as test trees for the Matsucoccus studies. Photographs were taken of these trees and later a professional tree climber was employed to secure branches from various levels of the crowns of these pines. The branches were then examined in the laboratory for scale presence and injury. The trees will be left standing so that further observations on them might be made. The results of these experiments are presented in this report.

Several rather pertinent questions have been raised regarding the role Matsucoccus plays in causing mature pine deterioration. These questions are listed below together with their tentative answers.

1. What is the type of injury which scales cause to a pine twig?

The most obvious injury caused by Matsucoccus scale is that produced by the feeding of these insects in the axils of twigs which results in a necrotic condition of the cortical tissue and which may ultimately become infiltrated with resin. The basis for this statement is discussed under Question 2. Infestations of this insect on the stems may also be associated with necrosis and resining, although present indications are that this is not the case.

2. Are scales always associated with necrosis and resining in twig axils, and if so, how many are needed to produce this condition?

This question can be definitely answered. Scales are almost always associated with necrosis and resining in twig axils. In the course of these studies 316 twig axils from branches of 8 mature ponderosa pines in Lassen and Shasta Counties, California, were carefully examined under the low-power binocular microscope for the presence of Matsucoccus scale, necrosis, and resining. Of this number 299 possessed some degree of necrosis or resining together with varying populations of scale. This data is compiled in tables 2 and 11.

Two or more scales are required to produce a necrotic condition which may ultimately develop into a resined lesion, and eight or more scales are necessary to cause heavy resining. See table 1 summarizing this situation.

3. Is the extent of necrosis and resining in the axils of flagged twigs greater than in those of green twigs?

The data presented in table 2 show that there is a considerably greater extent of necrosis and resining in the axils of flagged twigs.

4. Does the extent of resining in twig axils show any relationship to factors of growth such as needle length and twig growth?

There appears to be a definite trend with regard to heavy axil resining, as produced by the feeding of Matsucoccus scale, and a shortening of current needles and twig growth. See tables 3 and 4.

5. Does the population of scales on the stems show a relationship to needle length and twig growth?

Unlike the Prescott scale, Matsucoccus vexillorum Morrison, where concentrations of the insects on the stems produce girdling lesions that ultimately kill the branch, this situation does not show such a

relationship. The effect of Matsucoccus spp. on the stems of branches on mature pines in northeastern California does not, on the basis of evidence at hand (see tables 5 and 6), appear to inhibit current needle or twig growth. It will be noted from these tables that in 3 cases heavy scale populations on the stem were associated with long current needle and twig growth. The explanation for this might be that this represented rather recent attacks by the scales, and the effect on the factors of growth here considered had not become apparent.

6. Does the resined condition in a twig axil ultimately cause death to the twig?

Judging from the results presented in table 2, the extent of resining in the axils of recently flagged twigs is greater than in those of green twigs, and it seems reasonable to assume, therefore, that resining contributes to the death of certain twigs, but ultimate proof that this condition always follows resining is lacking.

7. Are scales more abundant on the stems of flagged twigs than on those of normal color?

According to the data presented in table 7, Matsucoccus spp. are more abundant on the stems of flagged twigs than on those of normal color.

8. Do low and high risk trees differ significantly in the scale population in different parts of the crown?

According to the data thus far accumulated as to the number of scales per square inch on the stems of both low and high risk trees, there does not seem to be any particular significance in the Matsucoccus population in different parts of the crown (see tables 8 and 9). On the other hand, however, if the extent of resining in the axils of the twigs from these trees (table 10) and others (table 11) is considered, the results are quite different, and heavy axil resining does appear to be more prevalent on high risk trees than it does on those of low risk.

9. Is there any "layering" in the scale population in the crown? That is, was the scale population more abundant in the top crown of the tested trees as it was that part of the crown showing the most advanced stage of deterioration?

According to the data presented in tables 8 and 9, the scale population on the stems of twigs was not always heaviest in the top crown. If the present knowledge of twig axil injury had been known at the time these trees were examined, the association of axil necrosis and resining with certain areas of deterioration in the crowns of the test

trees might have been more pronounced. In support of this statement attention is again directed to the data already accumulated on the axil condition of recently flagged twigs cut from the 4 Warner's Bridge trees that shows that resining was greater in axils of the recently flagged twigs than it was in those of the green twigs (table 1). This strongly suggests, then, that scale injury is more closely associated with that part of the crown exhibiting the most advanced stage of deterioration.

10. How many sampling units are needed from each tree to furnish an adequate estimate of the scale population?

From this study of the distribution of scales on the stems of trees it appears that approximately 50 samples are needed from each tree to yield a sampling error of 15 percent in 19 cases out of 20. Approximately 30 samples per tree would be needed to yield a sampling error of 20 percent. These data apply only for sampling the scale populations on the stems, and the sampling which has been made appears to be adequate. Preliminary data on crotch examinations tend to show that a much smaller number would be needed for this work to yield the same degree of accuracy.

11. On the basis of the answers shown by the above summarization what line of attack can now be followed to further our knowledge of this problem?

Three major lines of attack are here recommended to further the knowledge of this problem. These suggestions are as follows:

(1) Further "quick" field analyses of twig axils from both high and low risk trees.

The discovery of axil resining as produced by feeding Matsucoccus should greatly facilitate field analyses of mature pines since it will no longer be necessary to observe the stems under the low power binocular microscope. It is suggested that this work be concentrated in the Hat Creek basin where the lumber companies are carrying on extensive lumbering activities.

Continuation of this phase of the investigation should have immediate practical application if it proves to be of value in increasing the efficiency of risk rating. It apparently has good priority in projects bearing on the defense program because of its application to sanitation logging in the protection of timber resources.

(2) Conduction tests to determine percent stoppage of food materials to the twig.

A furtherance of this work might well be done in the field where fresh twigs will be available a few minutes after the trees are felled. This type of experiment might bring out even

more strongly the role Matsucoccus plays in producing twig axil resining which subsequently affects the needle and stem growth.

(3) A detailed study of cell destruction in affected twig axils.

Fresh twig axils could be collected in the field from recently felled trees, and preserved for future sectioning at the Berkeley Laboratory. This phase of research seems quite essential to an understanding of what happens to the affected cells.

Table 1. Number of Scales Required to Produce Various Degrees of Necrosis and Resining in Twig Axils of both Green and Recently Flagged Branches*

Extent of Necrosis	Number Axils Examined	Total No. Scales Found	Average No. Scales per Axil	Extent of Resining	Number Axils Examined	Total No. Scales Found	Average No. Scales per Axil
Heavy	8	54	6.75	Heavy	57	503	8.82
Medium	14	65	4.64	Medium	37	217	5.86
Light	9	19	2.11	Light	24	104	4.33

* These branches were cut from 4 mature ponderosa pines on the Warner's Bridge Climate Plot in Shasta County, California.

Table 2* Comparison of Twig Axils of Green and Recently Flagged Branches on 4 Mature Ponderosa Pines, Shasta Co., Calif., for the Association of Matsucoccus Scale with Necrosis and Resining.

Tree Number & Risk	Condition of Branch	Axil Infestation	Number Axils Examined	Extent of Necrosis in Axils (percent)				Extent of Resining in Axils (percent)			
				Heavy	Medium	Light	None	Heavy	Medium	Light	None
197 (Risk 4)	Green	Scales present	36	8.3	5.5	2.7	0**	58.3	36.3	2.7	2.7
		Scales absent	4	0	0	0	0	0	0	0	0
	Flagged***	Scales present	30	23.3	10.0	0	0	63.6	26.6	3.2	6.6
		Scales absent	1	0	0	0	0	0	0	0	0
211 (Risk 4)	Green	Scales present	12	0	16.6	25.0	0	8.4	16.6	25.0	50.0
		Scales Absent	1	0	0	0	0	0	0	0	0
	Flagged	Scales present	8	12.5	0	0	0	62.5	37.5	0	0
		Scales absent	2	0	0	0	0	0	0	0	0
183 (Risk 1)	Green	Scales present	27	18.5	22.2	11.1	0	18.5	18.5	37.1	25.9
		Scales absent	2	0	0	0	0	0	0	0	0
	Flagged	Scales present	2	0	0	0	0	100.0	0	0	0
		Scales absent	0	0	0	0	0	0	0	0	0
182 (Risk 1)	Green	Scales present	22	4.5	4.5	9.1	0	19.0	29.0	43.0	9.0
		Scales absent	3	0	0	0	0	0	0	0	0
	Flagged	Scales present			No samples on tree						
		Scales absent									

* This table includes 3 twig axils showing one or two scales but no necrosis or resining.

** As far as can be determined necrosis is a forerunner of resining. Consequently, the figures in this column cannot be accurately supplied because in so many cases medium and heavy resining undoubtedly obliterated necrosis. For this reason the figures in the heavy, medium and light columns will not add up to 100 percent.

*** Although several twig axils from flagged branches were examined that showed no scales, necrosis or resining it should be understood that these axils were but one of many on the whole flagged branch, and that the remaining infested axils probably contributed to the actual death of the branch.

Table 3. The Effect of Axil Resining on the Growth of Current Needles on Twigs Cut from 4 Mature Ponderosa Pines, Shasta County, California.

Extent of Resining	Current Needle Length (in inches)					Average Current Needle Length
	0.5-2.5	2.6-4.5	4.6-6.5	6.6-8.5	8.6-10.5	
Light		2	2	9	2	6.6
Medium	5*	5		5	2	5.3
Heavy	17	3	1	4		3.1
Total	23	9	3	18	4	

* Axils examined under low power binocular microscope.

Table 4. The Effect of Axil Resining on the Current Stem Growth on Twigs Cut from 4 Mature Ponderosa Pines, Shasta County, California

Extent of Resining	Current Stem Growth (in inches)					Average Current Stem Growth
	.1-.4	.5-.8	.9-1.2	1.3-1.6	1.7-2.1	
Light	3*	7	4		1	.70
Medium	5	11	2	2	1	.73
Heavy	11	11	4			.54
Total	19	29	10	2	2	

* Axils examined under low power binocular microscope.

Table 5. The Effect of Stem Infestations of Matsucoccus Scale on the Growth of Current Needles on Twigs Cut from 4 Mature Ponderosa Pines in Shasta Co., Calif.

Average No. Scales per In.	Current Needle Length (in inches)					Average Current Needle Length
	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	
0.1-5.0	11*	25	10	34	3	4.7
5.1-10.0	14	22	4	29	7	4.6
10.1-15.0		5			3	5.5
Total	25	52	14	63	13	

*/ Unit samples. Each unit sample includes approximately 1.75 square inches of bark surface that was examined under the low power binocular microscope for Matsucoccus scale.

Table 6. The Effect of Stem Infestations of Matsucoccus Scale on the Current Stem Growth on Twigs Cut from 4 mature Ponderosa Pines in Shasta Co., Calif.

Average No. Scales per In.	Current Stem Growth (in inches)					Average Current Stem Growth
	0.1-0.4	0.5-0.8	0.9-1.2	1.3-1.6	1.7-2.7	
0.1-5.0	31*	47	3	2	3	0.61
5.1-10.0	21	26	31	3		0.74
10.1-15.0		5			3	1.10
Total	52	78	34	5	6	

*/ Unit samples. Each unit sample includes approximately 1.75 square inches of bark surface that was examined under the low power binocular microscope for Matsucoccus scale.

Table 7. A Comparison of Stems of Green and Recently Flagged Twigs from 4 Mature Ponderosa Pines, Shasta Co., Calif., for Population Density of Matsucoccus Scale.

Tree Number	Green Twigs				Flagged Twigs				Remarks
	Number Samples Examined	Bark Surface Examined (sq. in)	Number Scales Found	Average No. Scales per sq. inch	Number Samples Examined	Bark Surface Examined (sq.in.)	Number Scales Found	Average No. Scales per Sq. inch.	
182 (Risk 1)	62	115.70	515	4.45	--	--	--	--	No flagged twigs available.
183 (Risk 1)	49	108.96	615	5.64	3	6.75	117	17.3	
197 (Risk 4)	74	145.52	905	6.21	65	93.59	953	10.1	
211 (Risk 4)	38	72.97	189	2.59	31	63.54	201	3.1	Samples too broken up for critical analyses

Table 8. Population Density of Matsucoccus Scale on Stems of branches in Various Crown Areas of 8 Mature Ponderosa Pines on the Modoc National Forest, California.

Crown Area	Average Population of Scale per Square Inch							
	Green Twigs	Twigs Collected Near Points of Injury	Green Twigs	Twigs Collected Near Points of Injury	Green Twigs	Twigs Collected Near Points of Injury	Green Twigs	Twigs Collected Near Points of Injury
	RISK I TYPES							
	Tree # 1		Tree # 2		Tree # 3		Tree # 6	
Top	2.0	--	2.7	--	12.9	--	2.4	--
Middle	4.0	2.0	1.6	0.6	12.5	--	18.5	8.0
Lower	2.7	--	1.8	--	25.8	17.8	1.8	--
	RISK IV TYPES							
	Tree # 4		Tree # 5		Tree # 7		Tree # 8	
Top	5.6	--	4.1	14.7	0.8	1.0	0.1	0.6
Middle	3.2	5.3	10.1	--	7.8	--	0.7	0.7
Lower	8.9	--	15.3	--	4.6	--	0.6	--

Table 9. Population Density of Matsucoccus Scale on the Stems of Branches in Various Crown Areas of 4 Mature Ponderosa Pines on the Warner's Bridge Plot, Shasta Co., Calif.

Crown Area	Average Population of Scale per Square Inch			
	Green Twigs	Flagged Twigs	Green Twigs	Flagged Twigs
	RISK I TYPES			
	Tree #182		Tree #183	
Top	5.1	--	5.9	--
Upper 1/4	3.5	--	6.3	--
Middle	5.1	--	3.8	18.6
Lower	3.6	--	5.6	--
	RISK IV TYPES			
	Tree #197		Tree #211	
Top	5.6	6.4	3.1	1.7
Upper 1/4	4.8	6.2	1.6	4.3
Middle	7.8	5.7	2.3	1.8
Lower	6.6	8.7	2.3	3.4

Table 10. Extent of Twig Axil Resining in Various Crown Areas of 4 Mature Ponderosa Pines on the Warner's Bridge Plot, Shasta Co., Calif.

Crown Area	Average Extent of Resining in Twig Axils							
	Number Axils Examined	Green Twigs	Number Axils Examined	Flagged Twigs	Number Axils Examined	Green Twigs	Number Axils Examined	Flagged Twigs
	RISK I TYPES							
	Tree #182				Tree #183			
Top	5	Light	-	-	9	Medium	-	-
Upper 1/4	5	Medium	-	-	7	Light	-	-
Middle	8	Medium	-	-	5	Light	2	Heavy
Lower	7	Light	-	-	8	Medium	-	-
	RISK IV TYPES							
	Tree #197				Tree #211 *			
Top	12	Heavy	7	Medium	3	Medium	1	Heavy
Upper 1/4	8	Medium	9	Medium	5	Light	3	Medium
Middle	8	Medium	9	Heavy	5	Light	-	-
Lower	12	Heavy	6	Heavy	-	-	5	Medium

* The twig samples from this tree were too much broken up, as well as dried out, for a very careful analysis of the axils.

Table 11. Extent of Twig Axil Resining in Various Crown Areas of 4 Mature Ponderosa Pines on the Black's Mountain Experimental Forest in Lassen County, California

Crown Area	Tree #1135		Tree #1443		Tree # 19		Tree # 99	
	No. Axils Exam.	Extent of Resining in Twig Axils	No. Axils Exam.	Extent of Resining in Twig Axils	No. Axils Exami	Extent of Resining in Twig Axils	No. Axils Exam.	Extent of Resining in Twig Axils
	RISK I TYPES				RISK IV TYPES			
Top	9	Light	11	Medium	30	Medium	10	Heavy
Middle	6	Light	19	Medium	23	Light	8	Medium
Lower	7	Light	13	Light	29	Heavy	0	No branches taken